# MEASURES OF ECONOMIC IMPACTS OF WEATHER EXTREMES

## Getting Better but Far from What Is Needed—A Call for Action

BY STANLEY D. CHANGNON

Improved estimates of economic impacts from extremes exist, but the values are still uncertain and adversely affect government and business decisions, an issue now recognized as a national problem needing attention.

Everyone recognizes that weather extremes cause financial losses, but the question is "How much?" Measures of the financial impacts of weather extremes are largely qualitative estimates, a situation often misunderstood by atmospheric scientists and many users of impact information. Ironically, the meteorological community frequently gets the blame for the questionable impact values. Four recent national assessments of hazards (Kunreuther 1998; Heinz Center 2000; Mileti 1999; NRC 1999) have pointed to problems of loss data, calling for better data needed to effectively guide government policies and business activities attempting to assess and address hazard risks.

**AFFILIATION:** CHANGNON—Changnon Climatologist, Mahomet, Illinois
**CORRESPONDING AUTHOR:** Stanley A. Changnon, Changnon Climatologist, 801 Buckthorn Circle, Mahomet, IL 61853
E-mail: schangno@uiuc.edu
DOI: 10.1175/BAMS-84-9-1231

In final form 14 March 2003


Unfortunately, assessment of losses has long been a very challenging problem for several reasons. Primary among these is the lack of systematic collection of loss data (outside certain sectors of the insurance industry). No one has been in charge of collecting and quality controlling natural hazard impact data. Hence, analysis of economic impacts of weather extremes has lagged until recent years, when increasing pressures for loss information led to a few assessments and new estimates.

Losses from and costs of weather extremes are difficult to assess for numerous reasons.[1] These include the fact that 1) there is extremely limited data available for some major impacts; 2) most impact data are difficult to access; and 3) available data are complex and hard to evaluate without multidisciplinary skills.

[1] Losses herein refer to market-based negative economic impacts and include the costs associated with the aftermath of extreme events.

The information available about direct losses and most costs (beyond government expenditures) is based on estimates developed by a wide variety of individuals and institutions using differing estimation approaches and data sources.

## UNCERTAINTIES IN ECONOMIC IMPACTS DATA AND AVAILABLE INFORMATION.

Wise use of data about economic losses from weather extremes requires understanding of the limitations in the loss values and the factors affecting their quality. In-depth studies of a few major catastrophic weather events including the 1988 drought (Riebsame et al. 1991), Hurricane Andrew (Pielke 1995), and the record 1993 Midwestern flood (Changnon 1996) have helped reveal how difficult it is to obtain meaningful estimates of actual losses.

Too often the people who must estimate losses are neither experienced nor skilled in this work. The oft complex assessment of the impacts of weather extremes requires adjustments for differences in data sources and time-changing conditions such as the growing population along the coasts. Such assessments require skills in economic analysis and the capabilities to wisely interpret highly different forms of data. Principal sources of loss data for weather events include government agencies (at the city, state, and federal levels), agricultural sources, insurance records, private businesses, field studies of events by experts in loss assessment, economic models, and environmental monitoring systems.

Another problem in loss assessment has been the lack of accounting of the delayed, indirect losses, as well as the economic benefits some realize from extremes. Those experiencing losses immediately seek aid, and losses are quickly estimated. Government relief actions are driven by political pressures to get emergency relief payments approved quickly. These near-event estimates are often limited, in that they do not consider losses occurring months and years after the event.

Reasonably good data available on losses include government and insurance payments for losses, but many losses are not insured. Insured losses, considered the most reliable measures of severe weather losses (NRC 1999), are shown in Table 1 for weather extremes during 1950–97. Also shown are federal payouts, which include flood insurance, related to weather disasters during 1953–97. Other natural hazards such as earthquakes and wildfires create equally costly losses but occur less frequently than weather disasters (NRC 1999).

Environmental damage due to weather extremes is another form of loss about which there is little economic data. Recent reports on natural hazards indicate that financial measures of environmental damage are needed but lacking (NRC 1999; Mileti 1999).

Benefits, both to the economy and the environment, result from most weather disasters, but these are seldom addressed or estimated. The focus of weather disasters has always been on financial losses, but some benefits also accrue. For example, the construction industry often realizes major additional income from the rebuilding efforts after a major disaster, as done after the 1993 flood (Changnon 1996).

## PROBLEMS FROM USING IMPACT DATA.

Major problems result from a lack of reliable data on the economic impacts of extremes and a lack of knowledge of the data limitations. Examples of certain problems are offered to illustrate these problems.

Since the 1980s, government relief for damages from extremes has grown dramatically and by the 1990s had become recognized as a threat to balancing the federal budget. One reason behind this escalation of presidential disaster declarations involved politics (Downton and Pielke 2001). It has been noted

**Table 1. Payments for losses (in 1997 dollars) due to property insurance catastrophes during 1950–97 and federal disaster relief payments (in 1997 dollars) for 1953–97 (Changnon et al. 2001; Sylves 1998).**

| Catastrophe | Insured losses* ($ billions) | Relief payments ($ billions) |
|---|---|---|
| Thunderstorms | 78.335 | 3.525 |
| Floods | 63.617 | 10.461 |
| Hurricanes | 59.082 | 8.653 |
| Tornadoes | 20.400 | 0.531 |
| Hailstorms | 8.530 | 0 |
| Winter storms | 8.452 | 1.253 |
| Wind storms | 8.062 | 0.112 |
| Drought | 0 | 0.286 |

*Shown is the primary cause of insured loss. For example, if an event's major thunderstorm components (high winds, lightning, heavy rains) caused greater losses than hail and/or tornadoes associated with the same system, the losses were assigned to the thunderstorm category.

that the issuance of a declaration and the amount of funding awarded can depend on whether the governor of a state with damages is a member or nonmember of the political party of the President (Sylves 1998). Another reason for the growth in payments was a lack of understanding of how impacts from extreme events were increasing as a result of societal shifts, including an ever-growing population (Changnon et al. 2000).

Meanwhile, the Clinton administration promoted disaster mitigation as a way to reduce the ever-escalating relief costs. Considerable funding was devoted to improving mitigation activities (Hooke 2000). However, the lack of reasonably accurate data on losses, both past and present, greatly limited assessment of how economically effective the mitigation expenditures had been (FEMA 1997). For example, the federal government and California invested $165 million in flood mitigation activities after the costly losses, roughly estimated at $2 billion (1998 dollars), from the 1982/83 El Niño storms. Flooding from storms during the comparable 1997/98 El Niño event in California caused losses estimated at $1.1 billion (Changnon 1999). Because the loss estimates are so uncertain, the difference in losses of $0.9 billion cannot be considered as a meaningful measure of the value of the mitigative activities (NRC 1999).

Another major problem occurred in the insurance industry. Insured losses from weather extremes began escalating in the late 1980s and reached all-time highs during the 1990s, with $40 billion in insured losses during 1991–94. The property insurance and reinsurance industry experienced major financial losses, nine firms became insolvent, and several firms withdrew coverage from high-risk areas. The property insurance industry had not effectively related insurance exposure to potential weather perils because it had never established a common database that recorded all losses for each weather peril. Hence, the industry had no sound basis for setting rates. They could not detect how shifting conditions, be they weather related or due to the shifting vulnerability of society, could impact them (van der Link et al. 1998). Business as usual did not work—the industry learned the hard way that the loss from an F4 tornado in 1994 was much greater than the loss from an F4 tornado in 1950 or 1964.

Informed decision making has been hampered by the lack of reasonably precise loss data. For example, a recent major assessment of the nation's natural disasters could only offer crude estimates of losses from weather extremes (Mileti 1999). For example, 20-year losses for tornadoes were cited as between $5.8 and $58 billion. Such ill-defined loss information limits informed decision making about the seriousness of each weather hazard and related research priorities.

Without a reasonably correct measure of today's losses, it is difficult to assess the potential future losses. Losses caused by many weather disasters (e.g., floods, hail, winter storms, and hurricanes) have increased over the past 10–25 years, and most of the increase has been found to be a result of societal factors including growing population, demographic shifts, increasing wealth, and poorer construction practices (Changnon et al. 2000). Future population growth and societal trends will likely continue to increase the loss potential, but adequate planning for a sustainable future society is limited by the lack of a more solid foundation of today's levels of loss (Anthes et al. 2001). This lack of knowledge about losses has also affected the setting of priorities for atmospheric research. Scientists have claimed that global warming will lead to more weather extremes, but the scientific community has not been able to offer convincing estimates of potential future losses that these extremes would create.

**THE GOOD NEWS.** Given the data limitations, questionable estimates, and resulting problems, what good news relates to the issue of economic impacts of extremes? Fortunately, the need to improve the estimates of the losses (and benefits) from weather extremes has become widely recognized during recent years as a national problem (NRC 1999; Heinz Center 2000; Kunreuther 1998; Mileti 1999). The rapidly growing federal disaster payments for weather losses led the Clinton administration to focus attention on the natural hazards problems facing the United States. Another factor driving efforts to better define losses was the governmental desire to measure the effectiveness of its mitigation efforts (NRC 1999).

The financial impacts of three recent exceptionally extreme events (1988 drought, Hurricane Andrew 1992, and 1993 floods) underwent in-depth studies, and these helped create new awareness of the data problems. Other activities addressed the need for better loss information. The U.S. Weather Research Program identified the issue as being critical to its research mission (Pielke and Kimpel 1997). The AMS recognized the need to enhance and present information about socioeconomic impacts among the atmospheric sciences and in 1996 established a special committee to enhance presentations of impact information. The AMS and the University Corporation for Atmospheric Research (UCAR) prepared two documents to provide guidance to the new (2001) administration and Congress about natural hazard issues (Anthes et al. 2001). Both documents were based on the seriousness of losses and costs resulting from weather extremes.

Other good news relates to results of recent impact studies that yielded updated and improved loss values. Some studies were motivated by concerns over global warming and its potential effects on extremes, whereas others were a result of the large weather losses of the 1990s suffered by the insurance industry and the government. Economists, geographers, and political scientists joined with atmospheric scientists to derive better estimates of economic impacts. For example, extensive assessments of past hurricane and flood loss data have undergone extensive assessments with time-adjusted values derived (Pielke and Landsea 1998; Pielke 2000). A two-year study of weather extremes using insurance catastrophic data yielded time- and risk-adjusted annual loss values for nine extreme conditions in the nation (Changnon et al. 2001). Resulting values, as shown in Table 1, are more definitive estimates of the nation's losses than existed before (NRC 1999).

**RECOMMENDATIONS.** It is widely recognized now that the nation needs a concerted effort, and a continuing program, to routinely assess and measure the losses from weather extremes and other natural hazards if it wants to adequately monitor the ever-growing impacts and to have policies that wisely address the issues. We are dealing with a moving target, a time-shifting vulnerability to weather extremes and other hazards. I and others envision establishment of a loss data collection center in a federal agency with the power and resources necessary to gather data from local, state, and federal agencies, from the insurance industry, and from the uninsured. A multidisciplinary staff with modeling capabilities is essential for improving loss estimates.

I would recommend establishing a lead agency for loss assessments within the Department of Commerce. This brings the economists and their measures of the economy together with the atmospheric scientists of the National Oceanic and Atmospheric Administration (NOAA). The agency would be responsible for compiling a comprehensive database containing the losses of all natural hazards. The database of dollars and human lives lost would form a matrix of types of loss (crops, houses, human lives, etc.) and would indicate who bore the loss (government, insurers, individuals, etc.). Data would be gathered for all hazards since weather and economic data need to be collected routinely to establish a baseline for assessing the impacts from extremes of varying types and magnitudes. State and local agencies, in addition to several federal agencies, need to be involved since they access vast and unique impact information at the local and regional levels. Similarly, the private insurance industry must be a cooperating member of the data collection process, providing loss measurement data to the lead agency. The industry's incentives to cooperate rely on the ultimate access to better overall loss data needed for improved risk assessment, a goal of the Institute of Business and Home Safety. Models of weather and losses will also be needed for those circumstances in which certain financial data cannot be accessed, such as damage to uninsured homes. Determination of event losses and benefits, both the direct and the indirect types using many sources of data, should be done by persons trained in numerous fields (weather, economics, environment, engineering, etc.). Training for such staff could be accomplished at universities with strong geography programs, a field of study that embraces the physical and social sciences. A new program to teach geographers about assessing the impacts of weather/climate is an example of the direction needed (Changnon 1998). It has been developed at Northern Illinois University through National Science Foundation (NSF) grants and private sector funding. Further thoughts on the dimensions of such a national endeavor are available (see NRC 1999).

## REFERENCES


Anthes, R., J. Fellows, B. Hooke, and R. McPherson, 2001: AMS/UCAR outreach to the Bush Administration and the 107th Congress. *Bull. Amer. Meteor. Soc.,* **82,** 987–994.

Changnon, D., 1998: Design and test of a hands-on applied climate course in an undergraduate program. *Bull. Amer. Meteor. Soc.,* **79,** 79–84.

Changnon, S. A., 1996: Losers and winners: A summary of the flood's impacts. *The Great Flood of 1993,* S. Changnon, Ed., Westview Press, 276–299.

——, 1999: Impacts of 1997–98 El Niño-generated weather in the United States. *Bull. Amer. Meteor. Soc.,* **80,** 1819–1827.

——, R. A. Pielke Jr., D. Changnon, R. T. Sylves, and R. Pulwarty, 2000: Human factors explain the increased losses from weather and climate extremes. *Bull. Amer. Meteor. Soc.,* **81,** 437–442.

——, J. Changnon, and G. Hewings, 2001: Losses caused by weather and climate extremes: A national index for the U.S. *Phys. Geogr.,* **22,** 1–27.

Downton, M. W., and R. A. Pielke Jr., 2001: Discretion without accountability: Politics, flood damage, and climate. *Nat. Hazards Rev.,* **2,** 157–166.

FEMA, 1997: Multi-hazard identification and risk assessment: A cornerstone of the national mitigation strategy. Federal Emergency Management Agency Washington, DC, 86 pp.

Heinz Center, 2000: *The Hidden Cost of Coastal Hazards: Implications for Risk Assessment and Mitigation.* Island Press, 123 pp.

Hooke, W. H., 2000: U.S. participation in the International Decade for Natural Disaster Reduction. *Natl. Hazards Rev.,* **1,** 2–9.

Kunreuther, H., 1998: Introduction. *Paying the Price,* H. Kunreuther and R. Roth, Eds., J. Henry Press, 1–16.

Mileti, D. S., 1999: *Disasters by Design.* Joseph Henry Press, 193 pp.

NRC, 1999: *The Costs of Natural Disasters: A Framework for Assessment.* National Academy Press, 78 pp.

Pielke, R. A., Jr., 1995: Hurricane Andrew in South Florida: Mesoscale weather and societal responses. ESIG, National Center for Atmospheric Research, Boulder, CO, 156 pp.

——, 2000: Flood impacts on society: Damaging floods as a framework for assessment. *Floods,* J. Parker, Ed., Vol. 1, Routledge Press, 133–155.

——, and J. Kimpel, 1997: Societal aspects of weather. Report on the sixth prospectus development team of the U.S. weather research program to NOAA and NSF. *Bull. Amer. Meteor. Soc.,* **78,** 867–876.

——, and C. W. Landsea, 1998: Normalized hurricane damages in the United States: 1925–95. *Wea. Forecasting,* **13,** 621–632.

Riebsame, W. E., S. A. Changnon, and T. Karl, 1991: *Drought and Natural Resources Management in the United States: Impacts and Implications of the 1987–1989 Drought.* Westview Press, 174 pp.

Sylves, R. T., 1998: Disasters and coastal states: A policy analysis of presidential declarations of disasters 1953–1997. Del-SG-1 7-98, University of Delaware, Newark, DE, 45 pp.

van der Link, G., and Coauthors, 1998: Why the U.S. is becoming more vulnerable to natural disasters. *Eos, Trans. Amer. Geophys. Union,* **79,** 536–537.